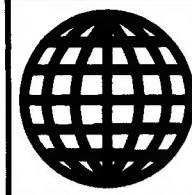


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19 November 1992



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# **JPRS Report**

## **Central Eurasia**

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**AVIATION & COSMONAUTICS**  
**No 3-4, March-April 1992**

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**Central Eurasia**  
**AVIATION AND COSMONAUTICS**  
**No 3-4, March-April 1992**

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### Problems With Support for Transfer Flights, Proposals Detailed

92UM1279A Moscow AVIATSIYA I KOSMONAVTIKA  
in Russian No 3-4, Mar-Apr 92 (signed to press 25 Feb  
92) pp 5-6

[Article by Military Pilot 1st Class Lieutenant-Colonel V. Skurikhin under the rubric "Combat Training: Experience, Problems, Opinions": "You Are 'Go' for Departure...—A Continuation of the Discussion of the Article by Lieutenant-Colonel V. Vysotskiy, 'The Stumbling Block, or the Problems of Combat Training'"]

[Text] The people have a saying—"If you want to get somewhere fast, take an airplane; if you want to get there on time, take the train." We have unfortunately often been convinced of the wisdom of that saying in practice. The pages of army aviation have talked repeatedly about the ordeals of crews connected with the performance of transfer flights by military aircraft and helicopters, and the disruptions in the rhythm of combat training due to it. But *plus que ça change...*

It is, you will agree, difficult to create fitting conditions for accommodation and rest, along with a food regimen, for the transfer crews (not to mention the flight personnel) in such difficult times for the whole country and for its army. But it does not sit right: why should people have to be forced—and namely forced—to live this life without amenities for weeks, and sometimes months (!), far from their own units, thereby depriving them of the opportunity of fulfilling their planned task in good time and returning to the base airfield?

We turn to an official document in order to seek an answer to this question. Here, for instance is what Article 120 of the NPP-88 [Manual of Flight Operations] says: "Commanders (superior officers) of all degrees, the CP and the YeS UVD [unified air-traffic control] centers are obligated to provide for the fulfillment of assignments by transfer crews in the stipulated time frames." All would seem to be correct. On paper... But in life? The structure of command posts that exists in the Air Forces and the extant system for the completion of requests for these flights does not so much help the crews in fulfilling the tasks assigned to them as, on the contrary, it serves as a drag on them in every way.

The point is that the structure that was created has in its chain a host of links that are called upon by intent to coordinate rapidly all issues pertaining to the performance of transfer flights and to get the needed information to the offices with an interest in it, but which in fact only introduce confusion into the completion of requests and the receipt of permission for departure.

I will elaborate with an example. Say a crew has to make a flight from military airfield A to military airfield B, but is in the zone of responsibility of another center of the YeS UVD. In accordance with the application filed in advance, the pilot "makes a request" to the air traffic controller of airfield A two hours before departure, after

which the request takes the following route: formation CP—military sector of the regional center (RTs) of the YeS UVD—zonal center (ZTs)—the allied ZTs where airfield B is located, and on down to its air controller. Finally, with the consent of the commander of the regiment, the decision is made on the readiness to receive the transfer traffic.

So the two air controllers have, with great difficulty, managed to establish "communications" between them, and airfield B is ready to meet the crew. But that is still not all, as the representatives of the military sectors of the RTs and ZTs of the YeS UVD are obliged to specify the final conditions for the performance of the transfer flight. And only after that does the "go" start its trip in the other direction. But... Taking into account the fact that it has literally had to "overcome the resistance" of our "non-Japanese" means of communication on its trip, the crew commander receives it either when the weather is bad or there is not enough daylight left for the flight.

The impression is sometimes created that the people who are occupied with questions of transfer flights at the YeS UVD offices enumerated above have absolutely no vested interest in the maximum number of such flights. Rather the reverse—the fewer that are flying, the less trouble (as they say, God forbid anything should happen). There is even a joke among the pilots that there is an officer who has never let a single aircraft go over his whole career sitting in one of the duty officer chairs at the RTs!

One can actually always cover one's negligence and sluggishness with a "concern" for flight safety—a means that is triggered without fail—any time it is needed. In life everything takes shape somewhat differently. When the crew receives the long-awaited "go" after prolonged ordeals, they cannot be held back—they are ready to fly into any weather... There's safety for you!

Most of the levels of the YeS UVD moreover simply ignore the requirement of the Instructions to support the transfer flights of aircraft and helicopters of armed forces aviation, where it is said that only a lack of conformity of the weather conditions can serve as the reason for delaying a crew's departure. In practice various reasons are sought out (aside from those weather conditions): lack of fuel at the airfield, hardstands for the transferring aircraft, places in the hotel to accommodate the flight crews, the request has supposedly not been completed, there is no plan for the flight, the communications gear is not operating reliably, the daylight hours are ending... What they won't come up with! Experienced pilots know that it is useless to "make a request" an hour before a shift change of the air controllers, during their meal times or in the days before days off. And it is thus not surprising that the commander of the crew has currently proved to be deprived entirely of the right to make the decision to depart (in accordance with the NPP), and thereby takes on himself the full responsibility for a favorable outcome of the flight.

One of the anachronisms in the organization of transfer flights, in my opinion, is the so-called "Excerpt From the Transfer Flight Plan," which should be sent around ten days ahead of departure. In practice, however, this document in most cases disappears without a trace into some office for reasons not known to anyone. And now a solid barrier is provided for the crew at one of the airfields—sit in good weather and wait for the duplicate copy to arrive. Finally the "papers" come—fly on. No one glances at their contents, the main thing is that they are there. But then how can we fail to complain the next time about our red tape, in whose power we remain to this day?

My crew, making a transfer flight on an Mi-26 not long ago, had to spend two days at a civilian airfield. First they could not allocate us any fuel, and then, after we had managed to refuel the helicopter anyway, the weather got bad. Moreover, typically, for some reason it got bad only for us military fliers. The transit civilian crews at that "point" were not delayed, since they received the "go" just half an hour after the request—if the airfield where they were headed was experiencing a shortage of fuel or the hardstands were occupied, they picked a different route and a different airfield; they were issued forecasts with a precision of up to an hour; all decisions were made quickly, without red tape (it was visible from everything that they do not keep superfluous people). I am surprised that the Air Forces command has not yet thought about why the crews of the aircraft of various ministries and agencies try in every way possible to avoid landing at military airfields?

I am profoundly convinced that the time has come to review the existing structure for air-traffic control points, cut back superfluous echelons and thereby make the Yes UVD really unified! Judge for yourself. The principal burden for the planning, coordination and immediate control of aircraft flights (including military) along the air routes and local air routes (MVLs) currently lies on the civilian sectors of its centers. The conclusion suggests itself in that case that the existence of military sectors of the Yes UVD centers is not expedient. It is worth leaving them only where it is exceedingly necessary, for instance in areas with intensive air traffic. I think that such a step would facilitate to a considerable extent the centralization of the UVD and the concrete delimitation of the management functions between its civilian and military representatives.

I cannot fail to refer to another fact in advancing this proposal. The decision was made, with the transfer of army aviation to the subordination of the ground-forces command, to deploy command posts for air control at them. Yet another (absolutely superfluous, I feel) level thus appeared in the structural chain of the UVD system, requiring additional expenditures of time for coordination with the Air Forces CP on all issues connected with supporting the transfer flights of military aircraft and helicopters! Commentary is superfluous, as they say.

Let us, however, trace how similar problems are resolved in the developed countries of the West. The Federal Aviation Administration—a purely civilian organization that operates successfully in the interests of all users—was created in the United States for the purpose of supporting UVD. Military representatives take upon themselves the control of transfer crews only in the areas of their own airfields. All seemingly the same way as here. But here is the difference: "over there" they control rather than command the air traffic! The crew of any agency thus transmits on automated control equipment a plan for the flight half an hour before departure (an analogue of our application), which arrives later at the UVD centers, which do not decide whether or not to give the "go" to the crew or not, but only control the aircraft.

Is the creation of such a streamlined system possible in our country—"taken separately"—and what is required for that? No one would resolve to give a positive answer to the first question, I think, in such troubled times for us. As for the second, I feel it expedient, first of all, to establish a direct link between the air controllers at the airfields and the representatives of the civilian sectors of the Yes UVD centers (with just concise information on the impending flight sent to its remaining offices) and, second, to institute differentiated material incentives for the individuals of UVD bodies (depending on the number of aircraft from various agencies they support). Then our Unified will start working for aviation and for the pilot.

I want to return to another and no less important problem that stands on the path of ensuring the timely departure of the transfer flight crew and the weather conditions connected with it. The crew commanders of the helicopters, as a rule, have a quite high level of flight training for difficult weather conditions, and many are permitted to fly on a routing with a cloud ceiling of 100 meters and flight visibility of 1,000 meters, and to make takeoffs and landing at 50 and 500 meters respectively day and night.

The aforementioned instructions define the minimum ceiling for transfer flights according on an MVL as 200 x 2,000 meters. They have in certain regions of the country issued (only it is incomprehensible on what grounds) their own—supplementary—instructions that dictate better weather conditions for the performance of transfer flights. When matters get as far as the RTs, its representatives (so as to protect themselves in some way) give the "go" for the departure at 500 x 6,000 meters. One might ask, then, why there are all these discussions about raising the level of training of the flight personnel for flights at minimum ceilings if, in the performance of the actual tasks, they become the principal drag on the transfer crews?

In conclusion I would like to dwell on something else. It is no secret that significant differences exist between the levels of navigational support for flights along air routes and the MVLs in the degree of sophistication of the

homing radio stations and the direction-finding equipment, the support of steady radio communications... As long as the crews of helicopters sometimes have to make transfer flights on MVLs without constant radar control and have to get oriented only by checking the map against the terrain, why not give them the opportunity of making flights along the air routes of the former USSR?

It must moreover be added that the fuel expenditure of helicopters decreases by 10—12 percent at altitudes on the order of 2,000—3,000 meters compared to the flying conditions at the ground (it is especially important not to forget this when making transfer flights in heavy rotary-wing craft of the Mi-6 and Mi-26 types). These altitudes are moreover usually free of aircraft flights. Their use would thus make it possible to make transfer flights in day and night under any weather conditions, even under minimum ceilings. And that means that expensive fuel and the service life of the aircraft would be economized—your and my money—and the crews would obtain the opportunity of returning to their bases on time to continue the fulfillment of their combat-training tasks without prolonged interruptions.

I would like to hope that the problems raised will not remain yet again outside the attention of the Air Forces leadership, and that they will be resolved soon. Let us all think first of all about the person.

#### Footnote

1. The Unified System for Air Traffic Control [*Yedinaya sistema upravleniya vozдушным движением*].

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#### Improvements in Assessment of Weapons-Delivery Training Suggested

92UM1279B Moscow AVIATSIYA I KOSMONAVTIKA  
in Russian No 3-4, Mar-Apr 92 (signed to press  
25 Feb 92) p 7

[Article by Candidate of Technical Sciences and docent Colonel V. Kazanov and Candidate of Technical Sciences Major S. Orlov under the rubric "For the Arsenal of the Combat Pilot": "A Criterion of Combat Proficiency"]

[Text] The training of flight personnel in the delivery of aviation ordnance is a most important type of combat training for them. The probability of destroying a target being attacked should thus be considered a chief criterion of the professional proficiency of a pilot. The four- and two-point systems that exist today for evaluating the quality of execution of ordnance delivery flights are based on a regard for the individual results of a random process, and thus do not meet the enhanced requirements for objectivity in evaluations and only facilitate over-simplification in combat training.

The essence of the latter is as follows. Only quantitative values are entered into the combat-training documents

before the start of the new training year—what the exercises are and how many flights must be made by the flight crew, how many missiles, bombs and shells are allocated etc. This planning naturally imparts a certain organization to combat training, and makes it possible to perform a precise accounting of the use of the combat allocation and aviation weaponry.

But drawbacks are also inherent in this at the same time that ultimately affect the quality of combat proficiency of the flight personnel. If, for example, it is planned that a pilot makes so many firings, launches or bombings over a year, the principal attention of commanders at all levels will be devoted to quantitative values (so that the plan is fulfilled) rather than the quality of weapons delivery. It is not surprising that the personal concern of the pilot for the quality of his combat proficiency in and of itself is relegated to the background in a situation where all efforts are concentrated on gross indicators. Just get a performance-graded evaluation. The overall evaluation for the flight is moreover determined according to the average points from evaluations of its elements.

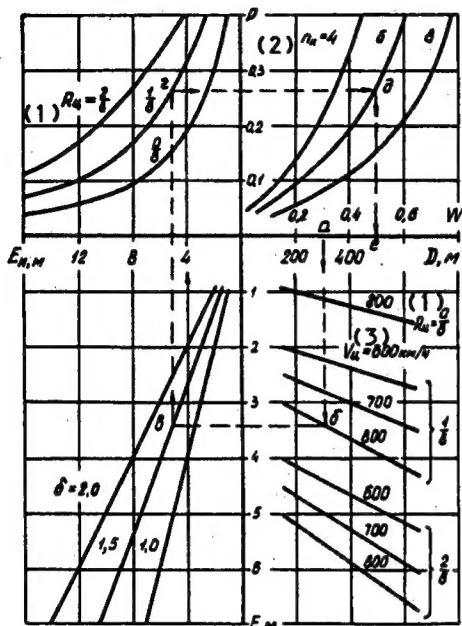
The existence of such concepts as "performance-graded" or "non-graded" in turn substantially reduces the objectivity of the overall evaluation for a combat sortie. The "grade" can be obtained, after all, by ensuring the values of the firing parameters being monitored close to either the upper or the lower limits of the allowable range of their variation. The effectiveness of the combat delivery of weapons in such cases, however, may not be the same. An ability to determine a trustworthy, and the more so summary, indicator for the effectiveness of weapons delivery in the form of the probability of the destruction of the target is thus of considerable practical interest.

One consequence of the official recognition of this value, it is expected, could be the increased role and significance of photofirings, photobombings and simulated launches of missiles in the course of training flights for weapons delivery.

It is namely such exercises for perfecting combat skills that are currently very rarely scheduled in the flight log of the pilot. An under-estimation of flights for photofirings, photobombings and simulated missile launches, after all, has a negative effect on the emergence of young pilots and on their later acquisition of skills in the combat delivery of weapons.

The process of determining the hypothetical probability of target destruction according to objective monitoring equipment (and it possesses quite broad capabilities on modern aircraft) is reduced to the use of specially computed nomograms whose initial parameters are the results of a deciphering of a weapons-delivery flight.

We will consider a technique for using nomograms based on an example determining the hypothetical probability of destroying an airborne target in photofiring (the nomogram is of an illustrative nature in this case).



Key:  
1.  $R_t$   
2.  $n_f$   
3.  $V_t$

Assume that the photofiring is executed from a range  $D = 300$  meters at a target aspect angle of  $R_t = 1/4$  against a target with a speed  $V_t = 800$  km/hr. The number of frames defining the duration of the sequence  $n_f = 6$ , and the precision of the vectoring  $\delta = 1.5$ . The sequence for determining the hypothetical probability of the destruction of an airborne "enemy"  $W$  is shown in the nomogram by the dotted line with arrows,  $a \rightarrow b \rightarrow c \rightarrow d \rightarrow e \rightarrow f$ , where  $a$  is the range to the target,  $b$  is the speed and target aspect angle,  $c$  is a descriptor of the aiming precision (the sighting mark is in the middle of the interval of allowable values for the vector error),  $d$  is the probability of one shell of an assigned type and target aspect angle hitting,  $e$  is an accounting for the duration of the photofiring and  $f$  is the value of the hypothetical probability of destruction  $W$  (in this case equal to 0.5).

The total hypothetical probability  $W_{\Sigma}$  in the performance of several photofirings in one flight is determined according to the formula

$$W_{\Sigma} = 1 - \sum_{i=1}^m (1 - W_i),$$

where  $W_i$  is the probability of hitting on one burst and  $m$  is the number of bursts.

Assuming that three photofirings are performed in flight, the hypothetical probabilities of target destruction in each are respectively equal to:  $W_1 = 0.2$ ,  $W_2 = 0.3$  and  $W_3 = 0.5$ . Then,  $W_{\Sigma} = 1 - (1 - W_1) \times (1 - W_2) \times (1 - W_3) = 0.72$ .

The use of the hypothetical probability of target destruction in photofiring, photobombing and simulated launches of missiles as a criterion for evaluating weapons delivery will make it possible to make a true judgment of the professional readiness of the pilot for the performance of this or that combat mission. The proposed technique can be used when evaluating the weapons delivery of the most diverse types of armaments.

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**Space Hardware Chief on Future of Space Units**  
92UM1279C Moscow AVIATSIYA I KOSMONAVTIKA  
in Russian No 3-4, Mar-Apr 92 (signed to press  
25 Feb 92) pp 8-9

[Interview with CIS Combined Armed Forces Space Hardware Chief Colonel-General Vladimir Leontyevich Ivanov by AVIATSIYA I KOSMONAVTIKA correspondent Lieutenant-Colonel V. Maksimovskiy under the rubric "Topical Interview": "Unified Space"]

[Text] April 12—Space Day—is a professional holiday for the personnel of the space units. Holidays are usually inclined toward reminiscences, but today all are more concerned with current and future problems. CIS Combined Armed Forces Space Hardware Chief Colonel-General Vladimir Leontyevich Ivanov relates to our correspondent what those problems are and how they are being surmounted.

[V. Maksimovskiy] Vladimir Leontyevich, the armed forces have ceased to exist in their prior form. What, in your opinion, are the consequences of that process for the space units?

[V.L. Ivanov] The military formations and facilities of the space units have been assigned to the Strategic Forces of the CIS, are under unified command and are intended to ensure the security of all the nations of the Commonwealth under the agreements adopted in Minsk on February 14 of this year.

Documents are currently being developed that define the concrete list and status of the facilities of the space infrastructure that are part of the Strategic Forces of the CIS, first and foremost the cosmodromes at Baykonur, Plesetsk and the command, control and telemetry complexes (KIK) located on the territory of five of the states—Belarus, Kazakhstan, Russia, Uzbekistan and Ukraine. Their signing will make it possible to create a legal foundation to ensure normal conditions for the functioning of our units.

[V. Maksimovskiy] Are there any specific features typical of military reform in the space units?

[V.L. Ivanov] Yes. And they are determined first and foremost by the necessity, under conditions of a sharp cutback in the military budget, of a further centralization of responsibility for orders, as well as for the application

of space hardware for military and dual purposes. Unified and monolithic space forces should be created within the structure of the armed forces of the CIS as the result of this centralization that would combine all the formations and units, as well as institutions, that are engaged in space activity. That would, in our opinion, substantially raise the potential of space hardware through the elimination of parallelism in operations and an expansion of opportunities for the utilization of the space infrastructure.

It must furthermore be taken into account that the demands on the personnel have not diminished, and many space units are performing their tasks continuously, around the clock. The questions that arise in the course of military reform on cutting them back and on the staffing and training of cadres are most closely connected with ensuring the required level of readiness of space units to fulfill their tasks in the interests of defense, the national economy and science of the states of the Commonwealth, as well as international collaboration.

[V. Maksimovskiy] Hasn't a drop in that level occurred already? What way out do you see from the current situation?

[V.L. Ivanov] I will say with complete certainty that the space units are still able to ensure the timeliness and completeness of the use of all space systems as before. But that cannot continue for long. The demands on the personnel of combat crews and duty shifts have increased sharply. The reliability of ground equipment has moreover decreased as a result of natural wear and tear and functional obsolescence. Some 66 percent of the equipment being operated in the command and control units and 80 percent of that in the launch units has gone beyond its guaranteed service life! The delivery of up-to-date models is possible only provided that logistical supply is maintained at its former volumes. Today, due to disruptions in the planned deadlines for deliveries and cutbacks in the financing of work on the creation of promising space hardware, the task of upgrading space hardware has not been solved in practice.

I see the way out of the current situation first and foremost in the fulfillment of the agreements that have been signed already on space and other issues pertaining to the armed forces of the CIS by each independent state.

[V. Maksimovskiy] What will happen if that is not ensured?

[V.L. Ivanov] It is well known that it is necessary to allocate more than 800 million rubles (in 1991 prices) for procurements of space armaments in 1992. A reduction in the annual volume of appropriations by 30 percent will lead to a reduction in the reserves of space hardware below the stipulated level starting with this year, and to its complete expenditure in 1995. If it drops by half, the orbital groups will cease functioning entirely in just one or two years!

[V. Maksimovskiy] Vladimir Leontyevich, the organization you head is the general customer for space hardware for military purposes. Will it be possible to create healthy competition in the development and production of space armaments?

[V.L. Ivanov] The system of orders for space hardware has been markedly altered due to the economic reforms and the transition to new conditions of economic management. All orders for both military and dual purposes are currently accomplished by direct contracts with us. This provides the opportunity to have an active influence on the attainment of the required tactical performance characteristics of the space complexes and systems being developed and to make broader use of the space hardware for military purposes in the interests of the national economy, as well as to create future systems on a competitive basis.

Taking into account that the creation of those systems requires considerable expenditures of material and time, we are striving to ensure competition among the developer organizations at the early stages, as a rule before the issue of the preliminary designs. We have already been considering a series of alternative projects, and have submitted them for expert appraisal.

[V. Maksimovskiy] And what is your attitude toward the commercial activity that has started in the army? Where are the funds from commerce being sent in the space units?

[V.L. Ivanov] The question of the creation and place of commercial structures in the armed forces has been discussed of late in the mass media, and polar opinions are often expressed on this problem. As for the space units, work is underway on the formation of commercial structures. But the problem itself is not a new one for us, we have been thinking about it and seeking ways of solving it for more than two years.

Things have taken shape historically in such a way that we—the military, performing the work to prepare for launch and launching the launch vehicles with spacecraft and controlling them in flight—have taken, and are taking, part in all space projects being realized in the interests of science and the national economy, including those being performed on a commercial basis in conjunction with foreign countries. All of that work has been accomplished through the military budget. A large portion of the spacecraft that we operate, as I have already mentioned, are moreover dual-purpose equipment—that is, used for both defensive and civilian purposes. Under conditions of cutbacks in appropriations for the needs of the armed forces and the space units, we are forced not only to pose the question of compensation for our expenditures for the performance of operations in the interests of science and the national economy, shifting them to a contract basis, but also to seek out additional sources of extra-budgetary funds for the implementation

of socio-economic programs in the interests of the servicemen and the development of the material and technical base of the cosmodromes and command and control stations.

We see that along with the sale of military hardware that has served out its time and freed-up matériel, a substantial impact could be obtained by offering our services on a commercial basis for the preparation, launching and orbital control of spacecraft, the applied utilization of scientific and military satellites, ground equipment and the intellectual potential of the space units, and the organization of visits by tourists to the cosmodromes and KIK facilities. We are now moreover resolving the issue of expanding access to information and the scientific and technical product obtained with the aid of military spacecraft, which will make possible a substantial expansion of the commercial utilization of space hardware.

Today, when the entire space sector is making the transition to market relations, the question of creating normal legal and economic conditions for the emergence and functioning of our own commercial structures takes on particular importance. This will make it possible for the space units to become full-fledged business partners. Whole subunits could be freed from the performance of tasks not characteristic of them.

[V. Maksimovskiy] The media talk more and more often about the deaths of servicemen in peacetime. Are there such incidents in the space units?

[V.L. Ivanov] As difficult as it is, I will say candidly that such cases do occur. Almost 90 percent of the space units, of course, go on for years without losses of personnel, and as the result of measures being taken the loss of people is ruled out in work on the very complicated and—I will not conceal it—dangerous space hardware, in the course of missile launches and the control of spacecraft in orbit. But that cannot console us. Servicemen, after all, are sometimes killed or injured as the result of accidents, violations of safety measures, domestic squabbles and in housekeeping chores, as well as due to the infamous "hazing" that still occurs in some units, despite the steps being taken to eradicate it. The loss of a soldier or officer in peacetime is a tragedy for the commander and the training officer, since the person is the measure of everything, there is nothing more dear than life. We proceed from that, putting its preservation at the forefront.

[V. Maksimovskiy] Can you say how many people have perished in disasters since the start of the space age, and what the material losses have been?

[V.L. Ivanov] Some 224 people have been killed in disasters with space-rocket hardware alone. The most terrible of those occurred in 1960 at Baykonur, when about 100 people were killed (among them was the commander-in-chief of the Strategic Missile Troops, M. Nedelin) by the explosion of a new intercontinental combat missile being prepared for launch, and later

another 62 from injuries and burns. There was also a tragedy at the Plesetsk cosmodrome. Nine people were killed on 16 Jun 73 in the launch of a Kosmos class rocket, as were another 49 in the launch of an R-7A rocket in 18 Mar 80. It must be said that there were no later accidents in the launches of space rockets that led to peoples' deaths. An explosion in the launch of the Zenit launch vehicle at the Baykonur cosmodrome on 4 Oct 90, which "cost" the space units a damaged launch pad and the loss of the launch vehicle along with the spacecraft, did not lead to any human casualties. And all that thanks to the fact that the launch of rockets like the Proton are carried out according to a new technological system of "fully automated launch," that is, all the hazardous pre-launch operations are performed either automatically or by remote control.

The space units irretrievably lost about 80 launch vehicles with various spacecraft—less than five percent of the overall number of launchers, which is somewhat better than in the United States—over the years of the assimilation of space. The average reliability of all existing launch vehicles, including those that are undergoing flight testing, is about 0.95 today, and that is a very high value.

[V. Maksimovskiy] The "greens" movement in Kazakhstan, as is well known, are waging an active struggle to curtail any testing of military hardware on their territory. How is your agency resolving questions of ecology in that regard?

[V.L. Ivanov] The space units have to encounter many ecological problems in the operation of rocket and space hardware. They are first and foremost the effects of the combustion by-products of rocket-fuel components on the state of ozone in the atmosphere, the toxic components of the fuel on the plant and animal kingdoms and the health of people in areas where the stages fall, as well as the pollution of space with fragments of space hardware.

We are interacting with many organizations and agencies in solving these problems, jointly developing and fulfilling comprehensive programs to reduce harmful influences on the environment. Starting this year we have been developing effective methods for neutralizing toxic components in the soil. Work is coming to a close on creating an experimental prototype of an assembly necessary for that purpose. The collection of separated portions of launch vehicles at the Baykonur cosmodrome, as has already been reported in the press, is being supported by two specialized battalions that have been operating since 1990. It was pointed out, true, that this is a subdivision of Glavkosmos [Space Chief Directorate]. But it is not a matter of imprecision, but rather that all the agencies strive to reduce the effects of space and rocket hardware on the environment. We have recultivated 1,120 hectares of lands over the past year. We have moreover turned more than 100 tons of non-ferrous metals over to the plants for reprocessing. The creation of a special set of technical means for the evacuation and

neutralization of the separated portions of launch vehicles is envisaged by 1995. But many measures were developed and have begun to be implemented in conjunction with representatives of the "greens" you mentioned above, within the framework of the "Kazakhstan—Kosmos" program, for the efficient utilization of the natural environment. We are also conducting research on the processes of the effects of combustible components of rocket fuel on the ozone content in the atmosphere.

[V. Maksimovskiy] The space units are operating the ground complexes for the Buran, launches of which are scarcely possible in the coming year or two. Won't that lead to an intolerable functional and physical deterioration of the equipment?

[V.L. Ivanov] The first launches of the Energiya-Buran general-purpose space transport system were made in 1987 and 1988. The next launch of the Energiya launch vehicle with an orbital ship is planned to be made next year.

The space units have been entrusted with the tasks of operating the ground complexes of the system, the preparation and execution of its launches, the control of the flight of the orbital craft and the support of its landing. Those facilities are being maintained in operable condition, for which regular check-ups and repairs of the equipment are conducted. It is also used for comprehensive testing in the process of preparing for the impending launch of the launch vehicle and the orbital craft.

It must also be noted that such unique facilities are created with their use planned for 15—20 years. The American space shuttle system has been operating since 1981, and no curtailment of its launches is planned in the next few years.

It must be said that a promising, ecologically clean heavy-launch vehicle of the Energiya-M class is currently being developed on the basis of scientific and technical work in progress on the Energiya—Buran system, and in the future it should replace the existing launchers of the analogous class that employ toxic fuel components. The ground equipment created for the Energiya will be used to perform testing and preparations for launch. That is why I feel it is premature to be talking about the functional and physical obsolescence of the ground systems. It is another matter whether the countries of the CIS will find the funds to fulfill that program.

[V. Maksimovskiy] And in conclusion of our conversation, what would you like to wish to those who are celebrating their holiday today?

[V.L. Ivanov] I want to express my sincere and heartfelt congratulations to all the workers of space on the professional holiday, and wish them first and foremost tenacity in life and social optimism in our difficult times. I am sure that however complex and difficult it may be, they will remain faithful to the chief life's goal—laying a road to the stars.

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### **Modern High-Precision Weaponry Close to Weapons of Mass Destruction**

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pp 10-11

[Article by Candidate of Military Sciences L. Malyshov under the rubric "Tactics in Combat Training": "High-Precision Weaponry—An Alternative to Nuclear?"]

[Text] *The selective execution of strikes using even conventional weapons against the most vulnerable locations of industrial facilities, command and control centers, reservoirs and the like could cause harm to any state that is commensurate with the use of weapons of mass destruction, and push the economic development of the victim of the attack back many years, in an era of the most complex technological processes and the integration of production. Many thousands of ground troops and tank armies to displace competitors from raw-materials markets and sales markets will not be required at all in the future. It is enough just to have effective weaponry and the means of delivering it. All of this is not the work of a feverish imagination. The augmentation of the rate of development and production of high-precision weaponry and its launch platforms—hard-to-detect aircraft—in the developed countries impels us to such reasoning.*

The technosphere—the production infrastructure—artificially created by man is extraordinarily brittle and susceptible to injury. Significant changes in nature and human society, sometimes irreversible, are likely in cases of the destruction or damaging of such key elements of it as AESs [nuclear power plants], GRESs [state regional electric power plants], petrochemical, chemical, biotechnical, metallurgical and other enterprises, reservoirs, transport centers etc. (as well as in extensive natural disasters). Major accidents at petroleum refineries, for instance, as a rule are accompanied by the burning of gigantic amounts of petroleum products and the release of heat, as in a nuclear explosion, on the order of 3—5 megatons, as well as the rapid spread of seats of fire across the entire enterprise. Smoke is released and soot settles out in the burning of oil and the end products of chemical plants that contain powerful poisonous substances—carbon monoxide, sulfurous anhydride, carbon disulfide, phosgene, hydrocyanic acid and the like—that form zones of chemical contamination stretching for tens, or even hundreds, of kilometers.

A number of the accidents that have occurred in the last 30 years at enterprises for the production of plastics or storage areas for hydrocarbon gases have been accompanied by the formation of enormous fireballs and huge explosions with shock waves that spread to a radius of 6—8 km. Some 3,150 people died, 20,000 became complete invalids and another 220,000 suffer from the consequences of poisoning with highly toxic gas as the result of the leak of 43 tons of methyl isocyanate at a

plant in the Indian city of Bhopal in 1984. The Chernobyl tragedy, which occurred in 1986, is analogous to the effects of a radiological weapon. It led to the radioactive contamination of about ten million hectares of land and about five million people.

The effects of production accidents on the ecology are becoming comparable in scope to the consequences of exposure to the direct and ancillary destructive factors of both the massed use of conventional weapons and weapons of mass destruction. The bombing of the cities of Dresden, Hamburg and Tokyo in 1943-45, for example, claimed no fewer lives in each of those cities than the number who perished (counting the consequences) in the atomic bombings of Hiroshima and Nagasaki. About 30 percent of the people, true, died from the direct effects of the explosions and burns. The rest died as a consequence of poisoning from carbon monoxide.

The use of modern conventional weapons, even on a small scale, can cause no less of an impact under contemporary conditions. That impact arises from the ancillary effects in the execution of strikes against the most vulnerable places of highly developed industrial production.

The verification of a new generation of high-precision weapons thus took place in the course of combat operations in the Persian Gulf: the Tomahawk naval cruise missiles and the SLAM cruise missiles (with a probable error of no more than five meters), as well as cluster weapons and pressure-effect ordnance. Facilities for nuclear power, the production of nuclear weapons, plants putting out chemical, biological and conventional weapons, petroleum-refining and chemical plants, oil pipelines and chemical plants, along with the troops, were subjected to their effects.

An unknown illness spread across the city of Baghdad after the destruction of a plant for the production of biological weapons there in February of 1991. Some 50 of the guards of that plant died and another 100 were brought to local hospitals in critical condition over just two days from the fast-acting illness. Unusual diseases took on the nature of epidemics from strikes against facilities of a similar type in Basra, Mosul and Timrit.

The strikes against Iraqi nuclear power plants and facilities for the production of nuclear weapons did not lead to reactor accidents, as the latter were taken out of operating mode ahead of time. Damage to the external elements of an operating AES—power lines for mechanisms of the safety systems and pipelines for feeding water to the reactor systems—using conventional weapons, however, according to research by a number of American scientists, could lead to its destruction and the release of a significant quantity of radioactive fuel to the outside. A modeling of the situation based on the example of radioactive-wastes and spent-fuel storage areas in the city of Gorleben (Germany) shows that the destruction of the heat-removal system even using conventional weapons could lead to the release of up to 90

percent of the radioactive elements, with an overall radioactivity of 140 million Curies, and the contamination of a territory stretching from 1,500 to 2,300 km and covering an area of 237,000 to 410,000 km<sup>2</sup> with more than 10 rems. These calculations are confirmed by the consequences of an accident at an analogous facility in the area of Chelyabinsk in 1957.

Specialists assume that a low-power nuclear blast is possible with the precise employment of conventional weapons (with the aim of compressing the heat-releasing elements in a limited volume). This would lead in turn to the intensive release of spent fuel components, which even after a year of operation in the reactor acquire radioactivity an order of magnitude higher than the initial amount.

The capabilities of high-precision weaponry are also testified to by an incident from the combat operations of the American Air Force in the Persian Gulf region. Two remote-controlled missiles were used to destroy electric-power plants: the first was intended to cut a blast hole in the solid wall, and the second struck the machinery room through the breach...

The contemporary situation in the developed countries of Europe, North America and the Far East, including those located on the shores of the Pacific Ocean, are typified by a high concentration of fire-hazardous, poisonous and radioactive substances on the limited territory of industrial-port complexes in 200 cities with a population of one million people or more. The energy of the "potential fuel" of each of the cities at the facilities of the city infrastructure is approximately 10,000 megatons. Petroleum, petroleum products, gas, coal, wood, plastics, polymers, industrial organics and the like all go there.

The overall capacity of AESs by the year 2000, according to forecasts, will be 150 GW/km<sup>2</sup> in the European portion of the former USSR and the European countries of NATO. The capacity of AESs in the United States (not counting Alaska) could reach 200 GW/km<sup>2</sup> by that time. High-precision weaponry, even with conventional charges, will under those conditions be a means of causing production accidents and secondary destructive factors that are large in scope (explosions, fires, floods, radioactive and chemical contamination). The destruction of key elements of the technosphere of warring developed countries could lead to irreversible changes, in both the natural environment and in their production infrastructures, that effectively correspond to an erasing of the boundaries dividing conventional weapons and weapons of mass destruction.

The events in the Persian Gulf revealed the new "outlines" of contemporary and future warfare using conventional weapons. The principal efforts of the warring sides, in the event a conflict arises, will be concentrated

to a greater and greater extent on the selective destruction of the economic base of the enemy and attempts (from purely humanitarian motives) to reduce direct human losses. Taking into account the constant threat of enemy use of nuclear weapons (although powerful mechanisms of restraint are also possible), the warring sides will strive for the pre-emptive mass use of the latest high-precision weapons in combination with reliable means of delivering them. The impact could be quite striking, seeing that there are no restrictions whatsoever here.

Large-scale armed clashes between developed countries in the future could call into question the possibility of the survival of all of mankind on the planet. In the future it is namely high-precision air-, sea- and even space-based strike systems—whose principal element will be hard-to-detect aircraft and cruise missiles with long range and conventional charges and integrated with the latest systems for command, control, information, reconnaissance, communications and the real-time entry of the flight assignment and guidance to the target—that will become the chief means of waging war using conventional arms.

The undermining of the economic and military might of the enemy and the assurance of the dominion of the victor over raw-materials and sales markets could be achieved by air force and naval groupings even without the seizure of enemy territory. The necessity will simultaneously disappear of maintaining an enormous quantity of traditional strategic nuclear forces and other weapons systems of mass destruction along with armies many thousands strong, as is already distinctly visible from the disarmament trends of the developed nations.

Several new tasks are immediately advanced before the world community in this regard: creating reliable means of control over the most dangerous types of high-precision weapons, along with weapons of mass destruction; developing measures for the radical improvement of the functioning of ecologically hazardous facilities, accidents at which in peacetime or the destruction of which in the course of combat operations could lead to global catastrophe; devising international legal standards with the aim of preventing the destruction of ecologically hazardous types of production with the start of combat operations, and increasing the responsibility of states to the world community for poor ecological standards in their economic and military activity.

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#### Information for Potential Entrants to Air Forces Schools

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[Article prepared by Lieutenant-Colonel V. Smirnov under the rubric "At the Higher Educational Institutions of the Air Forces": "For Those Who Choose the Sky"]

[Text] The recruitment of youth to the military educational institutions of the Air Forces—the flight, navigation, engineering and aviation technical schools—takes places each year. The flight schools produce pilots for all the branches of aviation—fighters, fighter/bombers, long-range and military transport, among others—while the navigation schools produce navigators for aircraft and air-traffic control officers. The engineering and aviation-technical schools train engineers and technicians for servicing aircraft (helicopters) and engines, aviation weapons, aviation and electronics equipment, weather specialists and aviation rear-support specialists.

Warrant officers who are on active military service in the armed forces (aside from a VATU [military aviation technical school]), conscript and extended-service servicemen, military construction workers, civilian youth, reservists from among the conscript servicemen discharged into the reserves and the graduates of the Suvorov military and Nakhimov naval schools and special boarding schools, with a profound knowledge of the Russian language, strong physical conditioning and secondary education and meet all the requirements of professional selection are accepted to the higher educational institutions. The acceptance of civilian youth and conscript servicemen to the Air Forces Engineering Academy imeni Professor N.Ye. Zhukovskiy began in 1989.

The age of those entering the Air Forces schools is stipulated as no older than 23 for warrant officers (provided they have served in the corresponding positions for no less than two years) and extended-service servicemen, no older than 23 for conscript servicemen, military construction workers and reservists from among conscript servicemen discharged into the reserves, and from 17 to 21 for civilian youth. The term of service and age are determined as of the year of entry.

A most serious attitude is needed toward the choice of field, since transfer from one school to another is not possible. The transfer of cadets from the flight schools to the engineering and technical schools is permitted as an exception (for reasons of health).

Servicemen desiring to enter a military educational institution submit an application in the name of the unit commander before April 1 of the current year. The application indicates the military rank, first, middle and last name, position held, year and month of birth, education and the military educational institution selected. A copy of the certification of secondary education, three certified photographs (4.5 x 6 cm, without headgear), an autobiography and a letter of recommendation are attached to the application. The candidates are discussed at a general meeting of the servicemen of the subunit, where the decision is made by open vote on further consideration of the candidacies for command.

The documents defined by the rules for acceptance are sent to the headquarters of the formation before April 5, with subsequent submission of the lists of names of

candidates to the military educational institutions before April 10. Professional selection cards and all materials filled out in the military unit are attached to them, along with information on permission to work at duty facilities if necessary.

Conscript servicemen selected for matriculation are sent for 25-day assemblies from June 5 to 30 at the higher educational institutions they will be entering. Training at these assemblies is completed with the passing of an entrance exam in one of the fields of discipline by the candidates. Servicemen who pass it successfully continue to take the rest of the exams, while those who receive an unsatisfactory evaluation or do not conform to other criteria of professional selection are sent back to their prior service location.

Civilian youth submit statements to the rayon or city military commissariat according to their place of residence before May 1. The statement indicates their first, middle and last names, the year and month of birth, the home address and the school selected. Attached to it are an autobiography, a letter of recommendation from the place of work or study, a copy of certification of secondary education (students at secondary schools submit information on their progress) and three photographs (4.5 x 6 cm, without headgear).

The rayon draft commissions of the military commissariats conduct the preliminary professional selection of the candidates during the period before May 15 (or sooner, to the extent of the arrival of statements). Medical cards are filled out for those who are worthy of being sent to study, and are deemed fit for training according to their health. Youth entering the flight and navigator schools undergo repeat certification at the oblast or kray military commissariats.

The rayon military commissariats submit all of the required documents on the candidates to the oblast or kray military commissariats, which then send them directly to the schools before June 5 after appropriate consideration. The candidates may send the documents directly, in the name of the chief of the institution, selected in the event that the military commissariats refuse to fill them out. The chiefs of the institutions report to the candidates on the time to arrive at the schools before June 30. The passport, military service card or certificate of registration, certification of secondary education and birth certificate are submitted personally to the acceptance commission.

The entrance exams to the higher educational institutions are conducted in the scope of the secondary-school program. The matriculants to the higher schools pass exams in the subjects of mathematics, physics, Russian language and literature (dictation), and to secondary schools in mathematics and Russian language and literature (dictation). Each candidate is moreover checked for physical training ("excellent" and "satisfactory" respectively for civilian youth are eleven and seven times for chin-ups, 13.6—14.8 seconds for 100-meter dash, 12

and 13 minutes 30 seconds for three kilometer cross-country running and 100 or 50 meters swimming).

The procedure for evaluating the general educational preparation effectively does not differ from those at higher and secondary civilian educational institutions. A candidate who disagrees with his evaluation has the right to complain under established procedure. The decision on enrollment at the school is made by an acceptance commission on the basis of the results for all indicators of professional selection.

Heroes of the Soviet Union and Heroes of Socialist Labor and the graduates of Suvorov military, Nakhimov naval and special boarding schools are accepted without verification of knowledge of general educational subjects, provided they conform to all the other requirements; so also are individuals who have completed secondary school with a gold or silver medal, or secondary special educational institutions or secondary professional and technical schools with an excellent rating, for the aviation-technical schools. Students at civilian higher educational institutions are also included in this category, but they can be enrolled only in the first year, and provided the field of their higher educational institution conforms to the field of the school. These candidates otherwise enter on a general basis. The decision to conduct an interview or have to take exams is made by the chairman of the acceptance commission.

Individuals who have completed secondary school with a gold or silver medal, or a secondary special educational institution or secondary professional and technical school with excellent ratings, and satisfy all other requirements are given exams in each of the fields of discipline. They are released from the further taking of exams upon receiving a "5," and take the exams in the remaining subjects when they receive a "4" or a "3."

The aviation schools are filled on the basis of competitive professional selection. The psychological inquiry is a unique barrier on the path of matriculants, especially when entering the flight or navigator schools. The study of the psychological qualities is made by specialists in the course of selection for the military units, military commissariats and in the work of the acceptance commissions right at the schools. The psychological inquiry of the candidates is performed with the aid of psychodiagnostic questionnaires and functional tests.

All candidates live in dormitories or barracks accommodations during the course of the professional selection, and are provided with free food according to the standards of conscript military service.

The term of study is four years at the flight or navigation schools, five at the engineering (six at the academy) and three at the technical schools. During the training period the cadets are provided with all types of sustenance (monetary, personal effects and food). They are given 30 days of leave and two-week holidays every year.

Those who complete the school are awarded the military rank of lieutenant, are issued the emblem and union-type diploma, and are given the qualification of pilot-engineer, navigator-engineer, engineer-mechanic, engineer-electrical mechanic, engineer-electrician, radio engineer, technician-mechanic, technician-electrical mechanic or radio technician.

#### Addresses of the Schools<sup>1</sup>

##### Flight and Navigation

Balashov Higher Military Aviation School imeni Chief Marshal of Aviation A.A. Novikov—412340, Balashov, 3, Saratov Oblast.

Barnaul Higher Military Aviation School for Pilots imeni Chief Marshal of Aviation K.A. Vershinin—656018, Barnaul, 18.

Yeysk Order of Lenin Higher Military Aviation School for Pilots imeni Two-Time Hero of the Soviet Union and Pilot-Cosmonaut of the USSR V.M. Komarov—353660, Yeysk, 7, Krasnodar Kray.

Kachinsk Order of Lenin and Red Banner Higher Military Aviation School for Pilots imeni A.F. Myasnikov—4000010, Volgograd, 10.

Lugansk Higher Military Aviation School for Navigators imeni Proletariat of the Donbass—348004, Lugansk, 4.

Orenburg Red Banner Higher Military Aviation School for Pilots imeni I.S. Polbin—460014, Orenburg, 14.

Syzran Higher Military Aviation School for Pilots imeni 60th Anniversary of the USSR—446007, Syzran, 7, Kuybyshev Oblast.

Tambov Higher Military Aviation School for Pilots imeni M.M. Raskova—392004, Tambov, 4.

Ufa Higher Military Aviation School for Pilots—450016, Ufa, 16.

Kharkov Order of the Red Star Higher Military Aviation School for Pilots imeni Two-Time Hero of the Soviet Union S.I. Gritsevets—310028, Kharkov, 28.

Chelyabinsk Red Banner Higher Military Aviation School for Navigators imeni 50th Anniversary of the All-Union Komsomol—454015, Chelyabinsk, 15.

Chernigov Higher Military Aviation School for Pilots imeni Leninist Komsomol—250003, Chernigov, 3.

##### Engineering

Air Forces Orders of Lenin and the October Revolution and Red Banner Engineering Academy imeni Professor N.Ye. Zhukovskiy—125167, Moscow, 167.

Voronezh Higher Military Aviation Engineering School—394064, Voronezh, 64.

Irkutsk Order of the Red Star Higher Military Aviation Engineering School imeni 50th Anniversary of the All-Union Komsomol—664036, Irkutsk, 36.

Kiev Higher Military Aviation Engineering School—252043, Kiev, 43.

Riga Higher Military Aviation Engineering School imeni Yakov Alksnis—226031, Riga, 31.

Tambov Order of Lenin and Red Banner Higher Military Aviation Engineering School imeni F.E. Dzerzhinsky—392006, Tambov, 6.

Kharkov Red Banner Higher Military Aviation Engineering School—310048, Kharkov, 48.

Kharkov Higher Military Aviation School for Radioelectronics imeni Leninist Komsomol of Ukraine—310165, Kharkov, 165.

##### Secondary Aviation-Technical

Achinsk Military Aviation-Technical School imeni 60th Anniversary of the All-Union Komsomol—662100, Achinsk, Krasnoyarsk Kray.

Vasilkov Military Aviation-Technical School imeni 50th Anniversary of the Leninist Komsomol of Ukraine—255130, Vasilkov, 3, Kiev Oblast.

Kaliningrad Military Aviation-Technical School—236044, Kaliningrad, 44, oblast.

Kirov Military Aviation-Technical School—610041, Kirov, 41, oblast.

Krasnodar Military Combined Flight-Technical School—350005, Krasnodar, kray.

Lomonosov Military Aviation-Technical School—188450, Lomonosov, settlement of Lebyazhye, Lenigrad Oblast.

Perm Military Aviation-Technical School imeni Leninist Komsomol—614049, Perm, 49.

5th Central Courses for Training and Improvement of Aviation Cadres—720055, Bishkek, Kyrgyzstan.

##### Footnote

1. Changes in the rules for entry are possible by the time of entry of matriculants due to the structural changes in the former USSR, especially in Ukraine, and the cutbacks or consolidation of some higher educational institutions or their transfer to other regions. Information may be obtained from the military commissariats according to place of residence.

## Problems of Spatial Perception for Carrier Landings Analyzed

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[Article by Lieutenant-Colonel V. Kolnogorov under the rubric "Flight Safety: Experience, Analysis, Problems": "Flights from a Carrier..."]

[Text] The specific basing conditions of ship-based aircraft (KLA)—such as the tossing of the ship, the restricted dimensions of the flight deck and the air disturbances over the flight deck and behind the ship in the area of the approach glide path that arise from the flow of air around deck superstructures—all pose increased requirements for coordinating the characteristics of constituent elements of the work system and the stability of its functioning under the effects of unfavorable factors as an essential condition for ensuring flight safety.

The safety level of takeoffs and landings for an aircraft-carrying ship (ANK) is the principal criterion determining the range of possible application of shipborne aviation. The indicator of flight safety will consequently predetermine the seagoing qualities of the ship, from the point of view of the possibility of its fulfillment of a combat mission using aviation as part of the overall system of requirements for the characteristics of ANKs.

Shipborne aircraft can currently employ various methods of takeoff (vertical, catapult and trampoline, among others) and landing (vertical and arrested, among others), in which the appearance of such special situations as the rocking of the KLA, a loss of altitude after leaving the deck, the failure to maintain the glide path and others are typical. The presence of on-board recording gear provides an opportunity for specialists to assess not only the state of the aviation hardware, but also the psycho-physiological features of the professional activity of the pilot and ascertain shortcomings in the organization of his interaction with the KLA equipment.

An analysis of the special situations that have been noted in takeoffs and landings of aircraft on ANKs has shown that the rocking of the pilot in roll and pitch is typical under conditions of a rolling deck. The parameters according to which one may judge the appearance of aircraft rocking are the nature of changes in the angles of roll and pitch, as well as the amplitude and rate of deviations of the aircraft control stick. The cause for its appearance is an incorrect assessment by the pilot of the attitude of the aircraft; the pilot tries to preserve it according to visual information from the space outside the cockpit.

A distorted idea of the true attitude of the aircraft arises for the pilot during separation of the aircraft in the perception of the outlines of the deck or the superstructures and the feeling of changes in the angular velocity  $\omega_x$  sep. The informational significance for the pilot of a

parameter such as the the roll of the KLA is quite great in this stage of the flight. The pilot is much more likely to use the information on the true roll obtained from the space outside the cockpit rather than from the piloting instruments therein. It should be kept in mind here that the pilot assesses altitude, lateral displacement, pitch and vertical velocity in this stage of the flight according to information from the space outside the cockpit. The likelihood of an incorrect assessment of the attitude of the aircraft is consequently comparatively large. This leads to the fact that the pilot, deflecting the stick to eliminate the "imaginary" roll, rolls the aircraft. He later tries to eliminate the roll, reflexively deflecting the stick with an amplitude and frequency that differ from the nominal values.

The pilot can fail to take into account differences in the rate of response of the lift and lift/cruising engines and allow their opposite response in a number of cases in piloting a vertical takeoff and landing aircraft, which will lead to an imbalance in the power plant in thrust and, as a consequence, the roll of the aircraft in pitch.

Research shows that the degree of significance of vertical velocity increases for the pilot in the concluding stages of vertical landings, with the most important source of the information becoming the space outside the cockpit. The pilot begins to assess vertical velocity in landing only starting at a certain altitude, due to the presence of differentiated thresholds of the sensitivity of the visual analyzer. When the ship is rolling, especially with the presence of a vertical component, additional interference is introduced into the actions of the pilot. The perceived values of this velocity will vary depending on the direction of movement of the deck.

The pilot's perception of a high value of vertical velocity of descent, with the factor of proximity of the ship acting on it, causes increased excitability of the motor analyzer. The movement of the engine controls at high speed leads to a thrust imbalance in the power plant. This phenomenon can also be manifested in the natural desire of the pilot to "soften" the landing.

The specific features of the control system for vertical takeoff and landing aircraft with an integral power plant do not rule out the likelihood of such phenomena occurring. This shortcoming is not always possible to be compensated for through the special training and preparation of the pilot.

The erroneous perception of the spatial attitude of the aircraft can also occur in a trampoline or catapult takeoff, especially under conditions of a lack of visibility of the horizon (in smoke, at night and the like). It is well known that the integral perception of the attitude of the aircraft in space arises from a complex visual image and a set of sensations caused by the action of inertial and gravitational forces. The perception of the attitude of the aircraft is made significantly more complicated for the pilot at the stage of trampoline or catapult takeoff, which is due to the rapidity of the process in which the G-forces

change, the angular velocities and the view of the space outside the cockpit relative to the natural horizon. This leads to a disruption of the usual correlations between the attitude of the pilot and the aircraft, the nature of the view and the action of forces that cause various changes in the organs and tissue of the body.

The aircraft sustains disturbances in movement along the deck on the trampoline, as the result of which the G-forces  $n_y$  increase and angular velocity  $\omega_z$  appears. After it leaves the trampoline  $n_y$  decreases sharply, while  $\omega_z$  sustains an impetus to alter it. Movement along the deck in a catapult takeoff occurs with a high  $n_y$ , while after leaving the deck the settlement of the aircraft occurs with a subsequent increase in the values  $n_y$  and  $\omega_z$ . A dynamic change in the parameters of aircraft flight occurs over the course of a short period of time, and then they stabilize within the assigned limits in the process of acceleration.

The pilot receives information on the attitude in space at the takeoff stage via a synthesis of the sensations from the inertial and gravitational forces and from visual information. The inertial and gravitational forces that arise in changes of  $n_y$ ,  $n_z$  and  $\omega_z$  act on the receptors of the vestibular analyzer, chiefly on the otolithic apparatus and the skin receptors. Impulses come in at the same time from the muscles and internal organs to the central nervous system, which provides the corresponding subjective sensations. An illusory perception of the spatial attitude of the aircraft can arise in the pilot when they appear, and with disruptions in the distribution of attention.

The pilot, in the face of dynamic changes in the flight parameters, perceives only part of the information (as a rule, the initial information), with the rest seemingly prediscerned, assumed automatically. In this case the angular changes in the attitude of the aircraft causes irritation to the semicircular canals of the vestibular apparatus, and are subjectively perceived by the pilot in the form of a rotation of the KLA even with a tendency toward stabilization of the parameters of the flight. Sensations arise of an increase in pitch that lead to the formation of a reflexive deviation of the stick away from oneself, with a failure to perceive the instrument information and the effects of the factor of a dangerous exceeding of the angle of attack.

A sensation of the settlement of the aircraft can be formed for the pilot with a sharp decrease in  $n_y$ . Taking into account the proximity of the surface of the water, he could reflexively pull up on the stick. The danger of exceeding the angle of attack is created as a result, since the departure of the aircraft from the trampoline is accompanied by high values for the angles of attack that are close to the critical ones. The factor of proximity to the water surface in a catapult takeoff has even more of an effect on the pilot. High values that do not conform to the nominal ones can be reached as the result of reflexive

movements of the stick, and that are hazardous from the point of view of the entry of the aircraft into stalling angles of attack.

The elements of functional non-conformity in the work system can also be manifested when landing on a ship. The moving, underlying surface of the sea and the rolling superstructure and deck of the ship are in the field of view of the pilot at this stage, and in combination with the inertial and gravitational forces in effect they cause him to have an illusory and unsuitable perception of the spatial attitude of the KLA and, as a consequence, the disorganization of actions in control.

Landing on an ANK with an arrester cable poses enhanced requirements, both for the precision of maintaining the flight mode by the pilot in the concluding stretch and for the landing characteristics of the aircraft.

It is natural to assume that the pilot correlates his actions in controlling the KLA with what seems to him to be the attitude of the aircraft relative to the flight deck. Foreign research shows that the pilot tracks the flight altitude, depending on the type of KLA, with a delay of two—five seconds. The longitudinal rolling of the ship is moreover in counterphase with the movement of the aircraft, which can be the cause of a failure to maintain altitude in the final stretch of the flight trajectory and lead to the rolling of the KLA.

The appearance of an illusory perception of spatial attitude in takeoff and landing is exceedingly dangerous, since erroneous actions of the pilot are formed as the result of its effects that he does not have sufficient time to correct (or counter). The technique for flight teaching must thus be strictly followed in order to devise solid knowledge and skills in the fliers making takeoffs and landings under the conditions for the use of shipborne aviation being considered. A knowledge of the mechanisms for the appearance of illusions and manifestations of discrepancies in the actions of the pilot and the behavior of the KLA in the process of preparing the crew for flights raises the likelihood that the crew will act in such cases in competent and aware fashion rather than reflexively. The appearance of elements of functional discrepancies in the work system will make it possible to determine their role in special situations, and to develop ways of improving aviation hardware and the system of crew training.

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#### History of Development, Service of Yak-28 Aircraft Series

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pp 18-20

[Article by I. Krivolutskiy and Ye. Gordon under the rubric "Domestic Aviation Hardware": "The Yak-28: Bomber, Interceptor, Reconnaissance Aircraft"]

[Text] A Yak-28—a monument to the era of the end of the 1950s to the beginning of the 1970s—has been mounted on a pedestal in front of the main entrance to the grounds of the aircraft plant. Those were years of intensive labor on the design engineering, building, testing, refinement and adoption into service of the whole family of "twenty eights," both for the workers of the plant in Irkutsk and for the staffers of the OKB [Experimental Design Bureau] of A. Yakovlev in Moscow.

Design engineering for the Yak-129 experimental light two-seat tactical bomber was completed in 1957. It was built on the basis of the Yak-26 aircraft, but had the more powerful R11A-300 turbojet engines. The development in prior years of the whole series of Yak-25, Yak-26 and Yak-27 type aircraft, which had a configurational layout close to that of the Yak-129, provided an opportunity for designers to make the transition to the creation of a craft of more advanced design.

Just how did the "Yaks" of this generation differ from the aircraft of other OKBs for analogous purposes? First and foremost by the engines, moved to under the wings, and the bicycle-type landing gear. Freeing the fuselage of the power plant made it possible to accommodate sighting systems, bombing armaments and a sufficient quantity of fuel in it.

The design of the Yak-129 underwent substantial changes—the wing area was increased through the development of a center plane and its thickness was reduced, with the leading edges of the wings moved forward and dropped down. The wingspan was increased by moving the wingtips outside the fairings of the wing outboard landing-gear struts. The wing was set high in order to ensure the necessary distance between the engines and the ground, due to the increased dimensions of the nacelles for the more powerful engines. A straight, slotted extension flap was installed between the nacelle and the fuselage instead of a slanted, swivel panel. The aerodynamic properties were improved thanks to the lengthening and increased sharpness of the nose portion of the fuselage, as well as the installation of a fence on the wing. A twin-canopy braking chute was installed in order to shorten the landing runout. The main rear strut of the landing gear was equipped with a "sit-down" system in order to increase the angle of attack in takeoff. A fully rotatable stabilizer improved the controllability of the aircraft.

The primogenitor of all later versions of the "twenty eight" family quickly completed plant testing and went into state tests. Upon their completion, the decision was made to launch the aircraft into series production in the tactical bomber (Yak-28) version. The bomb load of 1,000 to 3,000 kg [kilograms] was located in a special compartment inside the fuselage. An NR-33 23mm cannon was also installed in the lower portion of the fuselage (on the right side).

The comparatively large-diameter fuselage (1.45 meters), freed of air intakes and engines, made it possible

to create one version after another with a minimum of design changes and refinements in series production. Two new versions of the bomber appeared in 1960—the Yak-28I and the Yak-28L—with completely different bombsight systems (the *Initiatiiva-2* and the *Lotos* respectively). The Yak-28P interceptor was created in that same year, distinguished by a new nose portion with the Orel radar set and a two-seat cockpit for the pilot and weapons officer according to the Yak-25 type. It had only missile armaments, and was intended for the interception of airborne targets at low and medium altitudes. The interceptor was adopted for series production after the completion of state testing at the aviation plant in Novosibirsk.

The MiG-21PF interceptor that was launched into series production in 1964 had better speed, acceleration and ceiling characteristics, which forced the designers of the Yakovlev OKB to seek out other solutions. The engines were moved to the fuselage, and... the Yak-28-64 appeared, with lateral air intakes, and which was a complete fiasco in its first two or three flights... It is not known who was able to provoke designer A. Yakovlev to reject a fully worked-out and in its own way logical configuration, but this hastily created project in 1964 was his last adventure to be "incarnated in metal" and go up into the sky. Similar projects at the OKB later never went beyond the stage of preliminary sketches and configurations on paper.

The Yak-28R tactical reconnaissance aircraft, distinguished by special equipment and the modified *Initiatiiva-2R* radar, was created on the basis of the Yak-28I in 1963. The series production of this reconnaissance aircraft was assimilated in record time by the Irkutsk Machine-Building Plant that put out the Yak bombers. Production continued until 1970, but only 138 Yak-28R aircraft were put out over the seven years.

This aircraft proved to be perhaps the most successful and long-lived representative of the Yak family, and was well accepted in the Air Forces units. Five interchangeable units of the most advanced reconnaissance equipment for the times were installed on it, providing in particular for the successful waging of nighttime aerial photographic reconnaissance and reconnaissance at supersonic speeds, as well as electronic surveillance with wide scan fields.

The Yak-28PP jamming aircraft was the last to be adopted into service, and was intended to perform the suppression of enemy radar equipment. The Yak-28P and Yak-28PP aircraft had some design differences from prior models. The cockpit canopy was increased in height, and its windshield was given a pointed shape through the replacement of the one frontal pane of glass with two side ones. Special gear was accommodated in compartments inside the fuselage instead of bombs.

A trainer version of the aircraft—the Yak-28U—was created as early as 1962 for the training of cadets at the flight schools: there were two separate cockpits for the

instructor and the pilot, located one behind the other in the nose portion of the fuselage.

It should be noted that the Yak-28 was continuously improved in series production. The R11AF-300 engines were replaced with R11AF2-300s in nacelles of a more aerodynamic shape, the navigator's cockpit glass was altered to improve the field of view and a coaxial GSh-23Ya cannon was installed (on the bomber), while the shape of the external tanks was also altered.

Poor acceleration in the range of supersonic speeds from Mach 1.3 to Mach 1.6 was a quite serious drawback of the Yak-28 aircraft. The fuel expenditures to achieve maximum speeds were thus so great due to this at increased external air temperatures that fuel reserves to return to the airfield of departure in these modes could fail to be enough. The engine air intakes had controllable

dual-position central taper that was lowered manually or automatically when achieving a speed corresponding to Mach 1.45 in order to reduce losses of thrust. There was nonetheless a "drop" of longitudinal acceleration in the range of Mach 1.30—1.45 in the process of aircraft acceleration, even with full afterburners on both engines.

The design changes and improvements enumerated above, the installation of a special autopilot and non-reversible boosters in the altitude control surfaces and ailerons and a number of other technical solutions facilitated a substantial increase in flight reliability and safety, a reduction in the demands on the crew, an improvement in tactical performance characteristics (see table), the field of view, stability and controllability, especially in the maximum operating modes of speed and G-forces and in special situations.

Basic data	Yak-28B	Yak-28I	Yak-28L	Yak-28P	Yak-28U	Yak-28R	Yak-28PP
Year of production	1959	1960	1960	1960	1962	1963	1965
Type of engine	R11AF-300	R11AF2-300	R11AF2-300	R11AF2-300	R11AF-300	R11AF2-300	R11AF2-300
Length of aircraft, meters	—	—	—	20.55	20.20	20.34	20.34
Takeoff mass, kg:							
transfer	—	18,080	17,465	—	—	17,645	17,845
normal	13,630	16,160	15,545	16,065	14,565	16,725	15,925
Top speed, km/hr	1,900	1,805	1,945	1,840	1,807	1,805	1,725
Service ceiling, meters	16,200	14,500	16,250	16,000	15,600	15,650	15,300
Service range, km	1,950	2,070	2,420	2,150	2,270	2,680	2,062
Takeoff run (at maximum engine thrust), meters	—	1,830	1,550	1,300	1,450	1,230	1,250
Landing runout (with braking chute), meters	—	700	—	620	780	850	700
Armaments	NR-23	NR-23 or GSh-23Ya	GSh-23Ya	2 x R-30, 2 x R-60	—	—	2 units of NUR*

\*—non-guided aerial rockets.

The aircraft of the Yak-28 family had an exceptionally simple takeoff and landing, thanks to the bicycle landing-gear configuration. The craft virtually took off itself, according to pilot testimonials.

All of the series-produced Yak-28s had identical wing span and area—11.64 and 35.25 m<sup>2</sup> respectively. The number of crew members also remained unchanged at two.

The last version of the Yak-28 aircraft—the Yak-28PP—was removed from service only quite recently. A flying copy of it was demonstrated at Kubinka in the summer of 1991 at the exhibition "Aircraft for the Aviation Museums of the World." Our Air Forces for the first time proposed an efficient method of employing obsolete combat aircraft instead of destroying them. Among them are the Yak-28 aircraft—one of the most interesting in domestic aircraft construction at the end of

the 1950s, and one of the few that had virtually no analogues abroad in its design configuration.

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#### Air Forces Failure to Adopt Lighting System Seen as Symptomatic

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[Article by Candidate of Technical Sciences Lieutenant-Colonel P. Ivanov, editor at the Department for the Servicing of Armaments and Hardware: "Do Not Turn Back From the Threshold"]

[Text] "...Imagine yourself, reader, in the cockpit of a fighter flying along in the darkness at an altitude of eight thousand meters. Not a single instrument is working. You

*do not know where your home airfield is located (there are no radio communications, no illumination inside the cockpit either, featureless terrain under the wing)...”—that is what was written in KRASNAYA ZVEZDA on 9 Jan 90 concerning a dangerous precondition to a flight accident in one of the aviation regiments. Whoever is not shuddering after these lines, imagine yourself ejecting after using up all the fuel, in the taiga, at night, at distances from the nearest human life that are enormous by European standards. Senior Lieutenant O. Maltsev was nonetheless able to bring the interceptor to the airfield in this virtually hopeless situation and land it, becoming the first military pilot awarded a prize by the Aviation Safety Fund (FAB).*

*Candidly speaking, I would like not all readers to feel themselves in the role of O. Maltsev in that situation, but rather just those who should consider themselves either directly or indirectly to blame for what happened. You can judge for yourselves to what extent those who will be talked about in the article should be assigned blame for the difficult situation that arose on board his aircraft. But first about a few other, outwardly completely unconnected, events.*

Special situations in flight due to the turnoff of the illumination inside the cockpit have arisen before as well. On a MiG-25 in 1976, on a MiG-27 in 1984 and on a Tu-22M in 1988, for instance. And here is one of the earliest cases. The disengagement of the cockpit illumination occurred in March of 1970 on a Tu-128 aircraft when performing flight-training tasks at night in bad weather conditions. The instrument boards and panels were plunged into darkness. The pilot was forced to illuminate the instruments with... matches. When they ran out, there was nothing left for him to do but give the command to the navigator to eject, and then to abandon the aircraft himself.

There were explosions in various years in the removal of the soft fuel tanks from An-12 aircraft and in the performance of technical maintenance on the Tu-16 aircraft, due to the use of conventional lighting in an atmosphere saturated with fuel vapors, that led to the deaths and maiming of individuals.

Three AL21F-3 engines were removed from service ahead of schedule about ten years ago. The cause of damage, worth hundreds of thousands of rubles, was microscopic burns on the compressor blades due to their being touched with lamps with backwards hook-up polarity.

The connection between the events cited—the list of which could be continued—is that they all could have been averted with the presence and use of chemiluminescent (KhL) light sources (KhIS), the unsuccessful attempt to incorporate which into military aviation will be discussed below.

Chemiluminescence is the release of light in a chemical reaction. The chief engineer of the Air Forces in 1982

entrusted one of his scientific collectives with determining the expediency of employing KhIS—light sources based on KhL-compositions created in our country in the 1970s—in servicing aircraft.

Experimental prototypes of KhIS with KhLK-530 (530 + 5—the maximum wavelength of the radiation being emitted in nanometers—yellow-green light) were utilized therein. The KhIS in design terms is a polyethylene container 140 mm in length and 15 mm in diameter with two glass ampules with a solution of KhLK components contained inside. The release of light begins after the destruction of the ampules (through the bending of the container) and the mixture of the solutions.

This is a light for one-time use. The brightness and duration of its illumination depend on the proportion and concentration of the solutions. The prototypes that were tested could be used for up to one and a half hours for illumination purposes, and for several hours after that for designating, for example, its own location. The temperature range for their use is primarily in the range of positive temperatures—the brightness and duration of illumination decrease along with the temperature due to the irreversible increase in viscosity of the solutions, but the illumination is renewed after the heating of the KhIS.

There is no sense in citing more concrete characteristics, since they can be altered by varying the proportions of solutions, the formula and the amount of the substances. There are, for example, so-called “flare-KhISs” that shine more brightly than the ordinary ones, but “burn” for only 3—20 minutes; there are now sources for blue and red light as well as the yellow-green KhISs.

It was established, as the result of research conducted on dozens of types of aircraft, that the use of KhIS in the servicing of aircraft hardware was possible (below is verbatim from the informational report of the deputy commander-in-chief of the Air Forces for armaments) “thanks to the superiority of KhIS over conventional lighting sources: smaller dimensions and weight; a variety of possible designs; explosion safety—the lighting is cold, and there are no causes of spark formation; and, the possibility of providing them to all who need them in case of emergency situations.” The opinions of the specialists of line units in specific areas of the application of KhIS were reduced to a supplement to the informational report. They testify to the fact that the KhIS can and should be used, regardless of the type of aircraft hardware being serviced, for emergency illumination when preparing an aircraft for flight and at technical inspection stations; in inspections and the installation and removal of units and assemblies in difficult-to-access places in an aircraft, and finding and eliminating defects; to designate locations for the hanging of armaments; to signal the crew when taxiing on the runway; to monitor the level of refueling with fuel and other liquids, and for emergency illumination of the cockpits in the event of failure of the principal and back-up lighting systems; back-up illumination of the cargo compartments of aircraft in loading, unloading

and securing in places where the crew members land; designation of the boundaries of taxiways, motor traffic roads and personnel routes at field airfields; emergency lighting in fire-hazardous areas, stores of fuels and lubricants and ammunition. The impact from the use of KhIS to inspect aircraft is conditioned, for example, by the possibility of eliminating the shading of a section being inspected.

The conclusions of the report also noted the expediency of employing KhIS for designating contaminated zones, traffic routes and targets on firing ranges. The topicality of the latter, for example, was confirmed in an analysis of the causes of the tragic error of pilot O. Barkalov when bombing at the MVO [Moscow Military District] training center, caused by the poor distinguishability of the existing means of designating the forward edge for the crews of the high-speed aircraft. True, this occurred under daytime conditions, but the multitude of casualties (one of which could be considered the fate of the pilot, who deservedly had the title of best bomber in the regiment) demands that we think about improving the means employed overall.

The report, aside from this information, also included the results of altitude/climate and physiochemical testing of KhIS.

A representative of the Air Forces armaments service—N. Sapronov—was familiarized with all of the working materials of the research in February of 1983. Everything, strictly speaking, ended there.

For reasons of the uncharacteristic nature of the assignment with the KhIS to the work subjects of the collective, the combination of that brief research with the intensive performance of planning operations and, most importantly, due to the still unshakable confidence that has been cultivated in the fact that "things are more visible higher up," its executors recalled the KhIS six years later as something exotic. The dangerous precondition to a flight accident with the aircraft flown by O. Maltsev and an explosion on a Tu-16 reminded them of the research on the KhIS that had been unjustifiably forgotten "on high." It unfortunately was a reminder only for some of its direct participants, since Lieutenant-Colonel N. Sapronov was already in the reserves, Colonel-General of Aviation V. Skubilin—who had predicted the impact from the use of KhIS—was retired and the report was in the archives.

Two years passed even after that, however, and consideration of the issue of adopting the KhIS had still not taken place. There is, in my opinion, a great deal in this that is incomprehensible.

To a written report to the deputy commanders-in-chief of the Air Forces for combat training, rear support, aviation engineering service and the chief of the flight safety service on the expediency of returning to the results of the research on the applicability of KhIS that was conducted in 1983, an answer came back only from the flight safety service.

A conference of representatives of the aforementioned services (with the exception of the Air Forces rear support services, which did not even answer the invitation) and the NII [scientific-research institute] that developed the KhLK and KhIS was nonetheless held in October of 1990 on questions of the expediency of employing them in military-aviation practice. The decision of the conference, based on the results of a discussion of the reports (according to the research in 1982-83 on achievements in the realm of KhLK and its application abroad and in our country) and after a demonstration of the opportunities for the use of KhIS on real aircraft hardware (a videotape of all this exists), asserted the following: "The use of KhIS is expedient for emergency illumination of the cockpits and compartments of aircraft; designation of locations of aircraft crew members who have been stricken; designation of targets on firing ranges; and, for illumination of aircraft hardware in difficult-to-access and explosion-hazardous locations."

Immediately after the conference, the chief engineer of the Air Forces was allocated funds to work out the tactical and technical requirements for the KhIS, but then something unforeseen happened—the developer of the KhLK, a person who essentially had a vital vested interest in the adoption of the results and the financing of further research, the presenter of a paper at the aforementioned conference and who had signed its decision (Paragraph 2 of the decision was on the offering of the KhIS by the developer organization)—suddenly declared his inventor's rights to the formula for the KhLK and refused to offer experimental prototypes of the KhIS. What was this—a result of agency feuding (the sector with KhLK topics had been "spun off" from his laboratory), or a belated insight into the poor quality of his own work? Repeated appeals to him and the leadership of the NII produced no results. The promised renewed discovery of the formula by the "spun-off" sector had already taken place in practice, but another year was lost, this time due to the ambitions of a man of science.

The author of the article is also taking account of the fact that KhIS could find extremely limited application in military aviation, since its drawbacks are substantial (one-time use and storage time of just a year, among others). But even that application would undoubtedly be effective, not to mention the prospects for the improvement and utilization of the KhLK. The fact that the story of the adoption of the KhIS that never took place is somehow typical is significantly more serious. And it is typical for an exceedingly broad range of problems—from purely technical equipment to the techniques for training and the adoption of progressive experience. It is sufficient to recall, for example, for how many years the path was laid for the highly efficient, automated Mayak-85 objective-monitoring system. Agency and individual ambitions, incompetence and a simple inability to understand and evaluate something new clearly continue to stand in the way of progressive ideas.

**Call for Systems Approach to Space Flight Safety**  
**92UM1279I Moscow AVIATSIYA I KOSMONAVTIKA**  
**in Russian No 3-4, Mar-Apr 92 (signed to press 25 Feb 92)**  
**p 40**

[Article by Candidate of Technical Sciences and Military Pilot 1st Class Lieutenant-Colonel S. Krichevskiy, cosmonaut/test pilot of the Cosmonaut Training Center imeni Yu.A. Gagarin, under the rubric "Problems of Space Science": "A Systems Approach is Needed"]

[Text] It is well known that an acceptable overall effectiveness of manned space systems (PKS) is impossible to achieve without the maintenance of spaceflight safety (BKP) at an acceptable level. This is conditioned by the constant increase in their cost, the increased complexity of the missions being performed and, as a consequence, the growth in the potential and actual harm caused by spaceflight accidents (LKP) and the preconditions to them.

These circumstances should be taken into account when formulating and realizing a strategy for the development of manned cosmonautics, which is extremely topical under contemporary socio-economic conditions.

An approach toward PKS as an autonomous man-machine system where people perform various types of functions under extreme conditions, and conditioned by the factors of space flight, is of fundamental importance when resolving problems of the safety of manned space flights.

Large PKSs at the same time create a potential threat as a consequence of possible uncontrolled flight and the likely destruction of ground facilities.

A whole set of topical issues connected with the necessity of ensuring BKP thus exists that encompasses all the elements of the space macrosystem—manned and unmanned craft, as well as the facilities located on Earth.

That is why a systems approach toward ensuring the safety of space flights is exceedingly important. Substantial experience has been accumulated since 1961, and an analysis of it leads to some alarming conclusions.

Open data on manned space flights (PKP) in the USSR and the United States over a thirty-year period up to 12 Apr 91 that has been published in the Soviet press was utilized for the research. The table presents information on the principal LKPs in the classes of "accidents" (A) and "catastrophes" (K).

No.	Year	Country	Type of PKS	Class of LKP	Number of fatalities	Stage of flight	Cause
1	1967	USSR	Soyuz-1	K <sub>1</sub>	1	descent from orbit	failure of parachute system
2	1971	USSR	Soyuz-11	K <sub>2</sub>	3	same	failure of airtight seal of craft
3	1975	USSR	Soyuz-18	A <sub>1</sub>	—	ascent	failure of launch vehicle (3rd stage)
4	1983	USSR	Soyuz-T10A	A <sub>2</sub>	—	ascent	failure of launch vehicle (fire at launch)
5	1986	United States	Space Shuttle, Challenger	K <sub>3</sub>	7	ascent	failure of solid-fuel booster (explosion)

An evaluation of the safety level of PKPs was performed according to this information for the criteria of flying time per LKP ( $T_{LKP}$ ), the accident rate factor ( $K_a$ ), describing the quantity of LKPs per 100,000 hours of flying time of PKSs with a crew on board, and the number of flights per LKP ( $n_{LKP}$ ).

The most optimistic assessments of the level of BKP with an overall total flying time  $T_{\Sigma} \approx 100,000$  hours (of which the share of the USSR is about 80,000), overall quantity of manned flights  $N_{\Sigma} = 141$  (of which 71 were from the USSR) and quantity of LKPs  $n_{LKP} = 5$  corresponds to the values  $T_{LKP} \approx 20,000$  hours,  $K_a \approx 5$  and  $n_{LKP} \approx 28$ .

The values of the indicators  $T_{LKP}$  and  $K_a$  effectively correspond to the level of the accident rate known from the open press in military aviation in the USSR and the United States, which objectively testifies to the presence of the enhanced risk of PKPs and, I think, the insufficient effectiveness of the prevailing approach to controlling the level of BKP.

One may forecast one LKP every 3–5 years with the continuous operation of the Mir orbital complex (OK) in manned mode and the prevailing level of flight safety, which coincides with assessments for the Freedom orbital station.

Among the principal factors posing the greatest threat to BKP may be singled out:

- the lack of ergonomic conformity of the hardware to the capabilities of the crew;
- the excessive complexity, diversity and intensity of the tasks being performed by the crew of restricted composition on the OK (especially when working in open space);
- the insufficient reliability of individual OK systems and equipment;
- the placement in the same space (in the overall gaseous environment of the OK) of the processes of life support for the crew and the functioning of technological installations and bioreactors;

- the possibility of the collision of spacecraft with the OK in convergence and docking;
- the increased likelihood of damage from man-made particles in orbit (space trash); and
- the limited opportunities for rescuing the crew in the event of emergency situations in orbit.

Cosmonautics is the sole sector in our country which, in resolving transport and other complex technical tasks, does not yet have a special structure managing the level of flight safety.

A unified database of information on LKPs and the preconditions to them is lacking in the country overall and at all "space" agencies and organizations.

The absence of a unified and automated system for the gathering, storage and processing of that information makes access to it more difficult and makes its operative utilization by various specialists virtually impossible. Economic substantiation and the direct financing of the essential expenditures for the comprehensive resolution of tasks in managing the level of BKP is also lacking in cosmonautics.

A modern conceptual framework for the prevention of LKPs does not exist in the sector, and there are no corresponding bodies or specialists who are professionally engaged in the prevention of accidents in space science.

The wealth of practical experience and achievements of aviation in the realm of flight safety is being ignored and not utilized, and a narrow departmental approach predominates.

This situation does not allow the implementation of the essential preventive measures to ensure the maintenance and rise of the level of BKP.

Analysis shows that the necessity of creating a special, authorized structure—the Space Flight Safety Service—has become urgent. It should be noted in particular that the question remains an open one to this day, despite all of this.

It would seem that the time for decisive actions has come. And the first concrete step should be the stage of developing and adopting an automated system for the gathering, storage and processing of information on events that threaten the safety of flights, which will be the core of the whole system of accident prevention. It is important therein to ensure the maximum utilization of the experience accumulated in domestic and foreign aviation and cosmonautics.

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### **Underwater Simulation Training for Cosmonauts Plays Large Role**

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[Article by two-time Hero of the Soviet Union, Cosmonaut/Pilot of the USSR and Candidate of Technical Sciences Major-General of Aviation A. Leonov and Doctor of Technical Sciences Colonel N. Yuzov under the rubric "Cosmonaut Training": "Hydro-Weightlessness"]

[Text] The entry of man into the limitless expanse of space—one of the greatest achievements of human reason—is based on a mighty foundation of theoretical and experimental research, design developments and comprehensive and purposeful simulations.

One result of the evolution of simulation equipment was the creation and entry into service in 1980 of a hydro-laboratory, which has occupied a worthy place among the laboratories and simulators of the TsPK [Cosmonaut Training Center] imeni Yu.A. Gagarin, many of which are unique.

A portion of the sea confined in an enormous reservoir 12 meters in depth and 23 meters in diameter, with a remote-controlled platform on which full-size mock-ups of space stations and ships are located, seems to appear before the gaze of a person visiting the hydrolab for the first time. The arsenal of technical gear includes diving equipment and a decompression installation. A diving service has been organized.

The hydrolab is currently one of the simulation complexes of the TsPK, which includes a large quantity of technological systems and equipment and various apparatus for objective monitoring, as well as specialized systems for service communications, television, video recording, illumination, automated information processing, air and oxygen supply, materials-handling machinery and electrical equipment. The hydrolab is widely used to perform testing of space hardware and experimental research under conditions of simulated weightlessness in a hydrosphere. The evaluation of elements and equipment for supporting work in open space, as well as the possibilities for fulfilling an assigned algorithm for operator activity, the running through of cyclograms and techniques for training cosmonauts are all important tasks here.

The first deputy chief of the training center, A. Nikolayev, was an energetic advocate and one of the organizers of the creation of the hydrolab. Such enthusiasts as V. Skachkov, V. Zinchenko, A. Moiseyenko and V. Markovets devoted many years to its creation.

March marked 27 years since the spacewalk, as made by a Soviet cosmonaut aboard the Voskhod-2. The outside suit and hatch equipment were tested at that time, and the possibility of a cosmonaut's exit from and return into

the ship was confirmed. Various types of operations have since been performed in open space (before the end of 1991) by 19 crews of Soviet space stations, including one international crew. They left their space home some 43 times. The overall working time in airless space has surpassed 169 hours 11 minutes.

A new type of professional activity for the cosmonauts had taken shape—so-called extravehicular activity, the main substance of which is the performance of scientific experiments, technological operations, the assembly of elements of large structures and technical maintenance, repair and restoration work. The first simulations under hydrospheric conditions were performed in 1976 in the preparations of Yu. Romanenko and G. Grechko for an inspection of the docking assembly of the Salyut-6 station. The successful completion of the flight introduced corrections into the methods of training cosmonauts, including the use of simulated weightlessness in a hydrosphere.

The decision was made for V. Kovalenko and A. Ivanchenkov to venture into space on 29 Jul 78, some 71 days after the last ground simulation in hydro-weightlessness. The program envisaged working with a large quantity of experimental equipment. The results of the work showed that skills acquired in the simulations according to the full cyclogram are retained for a long time. This made it possible to make later decisions on the performance of work outside a craft after a considerable amount of time had passed since the end of the simulations. These conclusions were taken into account when training the crew of V. Lyakhov and V. Ryumin for a 175-day flight, who made a non-standard spacewalk to eliminate an emergency situation caused by the fact that the KRT-10 antenna had snagged on structural elements of the orbital station. The good results provided an opportunity to plan later installation, dismantling, repair and restoration work across the whole surface of the station, but with the preliminary ground practicing of the routes for movements in the hydrolab.

The installation of additional solar arrays and work with interchangeable equipment was planned for the crew of V. Lyakhov and A. Aleksandrov, with a regard for the experience gained, in order to maintain the operability of the Salyut-7 station. It is noteworthy that the necessity of such operations was taken into account when creating the station. The crew required 14 simulations in hydro-weightlessness in order to instill solid skills.

Spacewalking came to be a common phenomenon with time. An unplanned walk by Yu. Romanenko and A. Laveykin was required, however, during a situation that arose in the docking of the Kvant module with the Mir station, in order to inspect the docking assembly and remove a foreign object. Romanenko had to move the 20-ton Kvant within the limits of the tolerances of the docking assembly. It must be said that this operation was first specially rehearsed in the hydrosphere, and the exit was performed in real time using mock-ups in the hydrolab.

The results of that work confirmed once again the correctness of the approach in which the architectural designs of the spacecraft and the complement of simulation equipment were determined ahead of time with a regard for the capabilities of a person in a space suit to perform the operations in space.

In giving a fitting assessment of the extravehicular activity of our cosmonauts, one involuntarily returns mentally to the start of simulations in the hydrosphere, to those now long-ago sixties. The first experimental research on the capabilities for the utilization of hydropools for the training of cosmonauts for activity under the conditions of space flight was performed at the TsPK in 1965 by an initiative group that included A. Antoshenko, A. Leonov, G. Shcherbakov, V. Znachko, I. Chekirda, V. Voronov and V. Kosatikov. The use of a full-size mock-up of the Voskhod-2 spacecraft and hydrosuits was proposed for that purpose. The latter were equipped with rubber chambers and pockets that were filled with the required quantity of air or materials to create neutral buoyancy for the cosmonaut (an unsupported state or hydro-weightlessness at an assigned depth). The proposed device made it possible to provide for six degrees of freedom and to work out the biomechanics and coordination of the movements of the cosmonaut and working operations when entering open space for the performance of various, uncomplicated installation and dismantling operations. The first experiments were conducted by test pilots dressed in hydrosuits. Life, however, insistently demanded the use of standard gear.

The start of work to utilize suits was laid down in 1966. This quite labor-intensive and complex task was resolved by the use of Yastreb suits with water cooling in 1969 and the Orlan suit in 1970. Various modifications of the Orlan suit later became the principal gear of the cosmonauts when performing simulations under conditions of simulated weightlessness in the hydrosphere. The work was performed using physical mock-ups of the orbital station and transport vessels in real time in a conventional swimming pool.

These simulations are complex types of operations carried out under unusual conditions of habitation, entail a real danger to health and are accompanied by increased emotional tension. All of this requires the use of special technical equipment, as well as special training for cosmonauts, instructors and specialists on the support teams along with the strict observance of measures to ensure safety.

The passage of time is inexorable. The experienced "trailblazers" of hydrospace gradually went to their well-earned rest. Young officers have come in to replace them. They have a high level of theoretical training, and a great desire to study the wealth of experience and learn all of the specific features of this difficult but absorbing work.

There is probably no doubt that a tendency exists toward a rise in the volume and complexity of tasks in extravehicular activity in the remote future. This is also confirmed by the concept that has been formulated for the large space facilities intended for the resolution of national-economic tasks, as well as the conception of a new class of space hardware, so-called means of technical transportation support, including interorbital tugs, acceleration units and means of docking, transporting, servicing and repairing craft right in space. The share of manual operations will be substantial therein.

It should be kept in mind that the advanced orbital stations will have very large dimensions. This will lead to the fact that their comprehensive rehearsal in the existing hydrolab will become problematical. Success in the coming work in open space, at the same time, will be far from the last thing determined by the level of ground training. And it will inevitably depend on how much the methods and training base correspond to the conditions and tasks of actual space flight. Whence objectively arises the requirement for constant improvement of both the systems for training cosmonauts and the simulation base.

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#### **'Space Regatta' Consortium Develops Interplanetary Sailing Craft**

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[Article by N. Sevastyanov, general director of the Space Regatta consortium, under the rubric "The 'Columbus-500' Program": "The First Space Sailing Craft"]

[Text] The idea of using the "solar wind" for space travel is quite old, but as yet not a single space sailing ship has ever been in flight. There are many reasons for this, but the main one is the complexity of the task. The pressure of the solar light within the limits of the Earth's orbit does not exceed one milligram per square meter. One must thus have hectares of sails in order to create sufficient thrust for movement in outer space.

And now the American anniversary organizing committee chaired by Dr. Klaus Hayes that is working on the Columbus-500 program has proposed marking the 500th anniversary of the discovery of America by Columbus with the launch of space sails created in the countries of Europe, America and Asia. They should be launched from a high near-Earth orbit and, slowly but continuously accelerating on a spiral trajectory, reach the environs of the moon and then Mars, delivering a prize banner and, possibly, other useful cargo there.

The founders of the competition have established the basic requirements for solar sailing vessels (SPKs): they should be placed into an initial near-Earth orbit over the course of 12 months starting 12 Oct 92, with a flight duration to the target of no more than five years, and the

movement and control of the SPK using only solar energy with the source of thrust a sail, the process of opening of which is autonomous, using the means of the sailing craft itself.

It was decided to consider as the winner of the regatta the craft that sequentially completes the largest number of the graded stages—reaching the environs of the moon; escaping the gravitational field of the Earth; and, reaching the environs of Mars—faster than the rest.

This "voyage," as 500 years ago, could provide an unexpected result and prove to have an appreciable influence on the development of mankind.

This competition attracted enormous attention. There proved to be several dozen participants. They were supported by many aerospace powers and firms known around the world. Three projects represented various creative groups from our country: from the city of Reutovo in Moscow Oblast, the Moscow Aviation Institute and Space Regatta collective from Kaliningrad near Moscow. This latter collective was formed from specialists from the Energiya NPO [Scientific-Production Association] and its traditional allied groups. It included veterans of space science who started their engineering careers under the leadership of S. Korolev, as well as young engineers. The project was headed by Doctor of Technical Sciences and Professor V. Syromyatnikov, known in particular for his designs of the docking assemblies of spacecraft, including for the Soyuz—Apollo program, and the deputy supervisor of the project was Doctor of Technical Sciences V. Branets, a specialist in the realm of spacecraft control systems such as the Soyuz-T and the Mir orbital complex. V. Koshelev, E. Belikov, A. Botvinko, S. Bova, V. Platonov and many other well-known and not as well-known creators of space hardware took active part in the work.

The American organizing committee selected the four, in its opinion, best projects. These were space sailing vessels from the United States, France, Japan and the SPK project whose development was begun by the Space Regatta group of enthusiasts. It included leading enterprises on these subjects, including the Energiya NPO as the principal developer.

Our specialists proceeded in selecting the design for the sailing craft from the fact that it should be light and compact, since the cost of putting the craft into orbit would depend on that. The SPK should be controllable. It was necessary to get by with a minimum of assembly operations in orbit, and to make maximum use of existing engineering and technological achievements of the space industry. The most important thing was to see that the space sailing craft was a prototype of a satellite that could be used for commercial purposes.

Proceeding from those requirements, a design for a sail was selected whose opening, the maintenance of its shape and the control were all accomplished using the principle of the gyrostat. The basic idea is that the mover of the SPK is two sails rotating in different directions

(for balancing)—the main (APO) and the controlling (APU). They consist of panels manufactured of a light-reflecting polymer film. The centrifugal forces that arise therein make it possible not only to unwind the film that was initially wound around a spool, but also to preserve the flat shape of the whole surface when opened up. The main sail makes one revolution a minute, while the controlling sail rotates at a speed six times faster, since it is smaller in size. The central shaft (TsV), with both of the bearing surfaces located at the ends of it, has two articulations in the middle. Kinetic moment is obtained through the deviations of the axis on which the controlling sail is located, forcing the SPK to turn in the needed direction. The sailing craft is controlled relative to its center of mass namely through that effect. This method makes it possible to forego the use of jet engines and the working medium required for that. The instrument-pod apparatus (PK) and the system of sail rotation receive electric power from the solar array (SB).

The absence of an airframe for the sail allows a significant reduction in the mass of the SPK and its dimensions in stowed form, as well as eliminating the expensive assembly of the ship in orbit.

This should be the first domestic space sailing craft.

Our country has proposed its own Proton launch vehicle to put a domestic and a foreign craft into a baseline orbit in 1993. A great deal needs to be done before a launch: develop and manufacture two (one back-up) SPKs and try out the assembly for opening the sail on a reduced model, but under natural conditions. This experiment is planned to be conducted in October 1992 using the Progress freight craft, on which a prototype of the flight assembly will be installed. The diameter of the open sail will be 25 meters, with its opening entrusted to cosmonauts of the Mir complex. They will be observing the spot of the solar light reflected from the sail onto the surface of the Earth at the same time.

The assembly and ground testing of a working model is currently underway. A great many experiments have also been performed to open the sail in a pressure chamber. The cost of creating two SPKs is estimated at 70 million rubles, with the expenditures for launch and control of the ship another 30 million.

We feel that our sailing craft will be sent to Mars without fail. But we do not consider that flight the ultimate goal of our work. We want the SPK to become a working prototype of a spacecraft that would, through its reflecting surfaces, provide illumination using solar light for certain sections of the Earth. A system of such satellites could make it possible to reduce the needs of cities for electric power and could be used in the interests of agriculture and for other purposes.

Therefore, after the craft has entered orbit but before it flies to the moon, it will undergo testing as a solar reflector. It is conceived that the back-up SPK, if it is not needed for the expedition to Mars, could be used in the interests of creating a system of space illumination. The

funds invested in the development of the sailing craft should thus bring direct benefit to people. It would seem that this direction will become a promising and advantageous method for using space hardware. This is the principal reason for the creation of the Space Regatta consortium.

#### Principal characteristics of the flight

Time of operation, years	3
Height of baseline orbit, km	50,000
Time of flight to moon, days	120
Time of flight to Mars, months	22
Maximum convergence to sun, km	$100 \times 10^6$
Maximum distance from sun, km	$280 \times 10^6$
Principal design data	
Mass, kg	500
External diameter of sail, meters:	
main	200
controlling	120
Mass of sail, kg:	
main	180
controlling	120
Distance between sails, meters	
	3.7
Area of sail, m <sup>2</sup> :	
main	180,000
controlling	120,000
Precision of orientation	no worse than 0.2 degrees
Speed of programmed rotations around axis, deg/sec, no more than:	
X	0.1
Y	0.03
Z	0.03
On-board control system structured on basis of on-board digital computer	

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